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Abstract

Recursive Least-Squares (RLS) algorithms are a family of widely-used techniques for adaptive parameter estimation and filtering. In many applications, a special structure in the estimation problem can be exhibited. This structure can be exploited to arrive at *fast* RLS algorithms. In this dissertation, we focus mainly on fast algorithms based on certain *shift-invariance* properties, and the particular filter structure considered will be a so-called *tapped delay-line or transversal* filter structure. Single-channel applications include high resolution spectrum estimation (AR modeling), noise cancellation, speech and biomedical signal processing. The multichannel algorithms (where each channel feeds a tapped delay-line) accommodate such applications as identification of systems described by difference equations with multiple polynomials (*e.g.* ARX and ARMAX models), adaptive minimum-variance control, fractionally-spaced and decision-feedback equalizers, multirate signal processing, image enhancement, and adaptive broadband beamforming.

Least-squares problems can be formulated in a vector space setting, and a geometric derivation is given for the basic *Fast Transversal Filter* (FTF) RLS algorithm, with a prewindowing assumption on the data. Next, the propagation of numerical errors through the recursions is investigated and the destabilizing effect of exponential weighting is exhibited. However, we show that the introduction of *computational redundancies* and an *error-feedback* mechanism can stabilize the error propagation, with a small increase in complexity. This numerical stabilization can be carried over to the multichannel FTF algorithms, for which a new modular form with sequential updating of the channels is introduced. The modular multichannel and multiexperiment form of the FTF algorithm allows for a convenient prewindowing framework that can accommodate the growing- and sliding-window covariance algorithms also. Finally, a connection to the *Chandrasekhar* algorithm, a fast version of the Kalman filter for time-invariant state-space models, is exhibited. The Chandrasekhar algorithm is shown to yield a general class of fast RLS parameter estimation algorithms, of which the FTF algorithm is just a particular instance.